Equilibrium Technology Diffusion, Trade, and Growth

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Complete replication package at https://github.com/jlperla/PerlaTonettiWaugh.jl

Big Picture

Big Questions:

- Why does opening to trade lead to productivity gains at the firm level?
- What are the consequences of these within-firm productivity gains for aggregate economic growth and welfare?

This Paper:

- A new theory of how openness affects a firms' decision to improve its productivity through technology adoption.
- Quantitative exploration of the gains from trade. Calibrate to micro-level firm moments and ...
  - Locally decompose the welfare gains from trade into direct and indirect effects arising from an inefficient decentralized equilibrium.
  - Globally compute the gains from trade—along the transition path—for a large change trade frictions.

Our Model...

Open economy, continuous time, GE extension of Perla and Tonetti (2014).

- Growth from technology adoption.
- Related to "idea flow" work by Lucas (2009), Lucas and Moll (2014), Alvarez et al. (2017), Sampson (2016), Buera and Oberfield (2019)

Trade as in Melitz (2003)...

- Heterogenous firms, monopolistic competition with fixed cost of exporting
- Free entry

Not a model of innovation or cross-country technology diffusion.

Main Results

1. Characterize growth as a function of statistics of the profit distribution—the ratio of profits between the average and marginal firm.

- Encodes the trade-off that firms face in technology adoption: the expected benefit versus the opportunity cost of adoption.
- Import competition erodes profits of low-productivity firms $\Rightarrow$ lowers opportunity cost of adoption $\Rightarrow$ more frequent adoption, faster growth via within-firm productivity gains.

2. Large welfare gains from trade—an order of magnitude larger than standard models (e.g. Arkolakis, Costinot, and Rodriguez-Clare (2012)).

- Almost all of the gains from trade are because the decentralized equilibrium has an inefficiently low growth rate due to the adoption externality.
- Direct consumption effects are small—like predictions of standard (efficient) trade models.
- Model predicts empirically plausible changes in growth. Micro-level firm dynamics matter a lot.

Model: Time, Countries, and Consumers

Continuous time, infinite horizon economy.

N symmetric countries

Consumers with period utility:

$$U_i(t) = \int_t^\infty e^{-\rho(\tau - t)} \log C_i(\tau) d\tau$$

$$C_i(t) = \left(\sum_{j=1}^{N} \int_{\Omega_{ij}(t)} Q(v,t)^{\frac{\sigma-1}{\sigma}} dv \right)^{\frac{\sigma}{\sigma-1}}.$$

- ρ = discount factor.
- $\Omega_{ij}(t)$ = varieties consumed.
- σ = elasticity of substitution across varieties.

Consumers inelastically supply L units of labor.

Model: Firm's Technology

Large pool of monopolistically competitive firms in each country.

Firms are...

- Heterogeneous over productivity, Z.
- Sole producers of variety, v.
- Have linear production technologies using labor, ℓ,

$$Q(Z) = Z\ell.$$

- Face fixed cost and iceberg trade costs to export.
- Have the option to pay a cost and receive a new productivity draw.

Overview of Firm's Optimization Problems

Incumbent firms' decisions can be divided into static and dynamic optimization problems and there is entry and exit.

Static Problem: Produce and Export. . .

Given Z, choose price and labor to maximize profits Π_{ji}, for each market j.

- Fixed costs (of hiring labor) to export to foreign market, affected by parameter $\kappa \geq 0$.
- Iceberg trade costs to ship goods abroad, $d \geq 1$.

Very standard. I won't go through this today.

Overview of Firm's Optimization Problems

Incumbent firms' decisions can be divided into static and dynamic optimization problems and there is entry and exit.

Dynamic Problem. . .

1. Non-adopting firms' productivity evolves exogenously according to geometric Brownian motion:

$$\mathrm{d}Z_t/Z_t = (\mu + \upsilon^2/2)\mathrm{d}t + \upsilon \mathrm{d}W_t,$$

- μ is the drift parameter,
- υ is the volatility parameter,
- and W_t is standard Brownian motion.

Overview of Firm's Optimization Problems

Incumbent firms' decisions can be divided into static and dynamic optimization problems and there is entry and exit.

Dynamic Problem. . .

2. Incumbent firms choose **when** to adopt a new technology, Z.

- Draw new productivity Z, related to **equilibrium** distribution $\Phi(Z, t)$.
- $X(t)$ is the cost (of hiring labor) to draw a new productivity, affected by parameter ζ.

Overview of Firm's Optimization Problems

Incumbent firms' decisions can be divided into static and dynamic optimization problems and there is entry and exit.

Entry and Exit. . .

- Entrants receive initial productivity from $\Phi(Z, t)$ at cost $\frac{X(t)}{\chi}$, where $0 < \chi < 1$.
- Exit at exogenous rate δ.

The Value of Adoption

In equilibrium, a firm's optimal technology adoption policy is a reservation productivity function, $M(t)$.

To make this choice,

- Firms must forecast the minimum productivity level of a non-adopting firm, $\hat{Z}$, since firms receive a draw only from producers.
- Firms must forecast $\Phi(Z, t | Z > \hat{Z}(t))$.

Thus, the expected value of a productivity draw at t is

$$\int V(Z, t) d\Phi(Z, t | Z > \hat{Z}(t)).$$

With rational expectations, $M(t) = \hat{Z}(t)$ in equilibrium.

Summary of a Firm's Dynamic Problem

1. The value function in the continuation region

$$r(t)V(Z,t) = \Pi(Z,t) + \left(\mu + \frac{\upsilon^2}{2}\right) Z \frac{\partial V(Z,t)}{\partial Z} + \frac{\upsilon^2}{2} Z^2 \frac{\partial^2 V(Z,t)}{\partial Z^2} + \frac{\partial V(Z,t)}{\partial t}$$

2. Value matching condition

$$V(M(t),t) = \int_{M(t)}^{\infty} V(Z,t)\mathrm{d}\Phi(Z,t) - X(t)$$

3. Smooth pasting condition

$$\frac{\partial V(M(t),t)}{\partial Z} = 0$$

4. Free Entry Condition

$$X(t)/\chi \geq \int_{M(t)}^{\infty} V(Z,t)\mathrm{d}\Phi(Z,t)$$

Law of Motion for the Productivity Distribution

The productivity distribution (with CDF $\Phi(Z,t)$) evolves according to the following Kolmogorov Forward Equation (KFE):

$$\frac{\partial \Phi(Z,t)}{\partial t} = \underbrace{\Phi(Z,t)\left(\underbrace{S(t)+E(t)}_{\text{adopt or enter}}\right)}_{\text{distributed below } Z} - \underbrace{S(t)}_{\text{adopt at } M(t)} - \underbrace{\delta\Phi(Z,t)}_{\text{Death}}\ldots$$

$$-\underbrace{\left(\mu - \frac{\upsilon^2}{2}\right) Z \frac{\partial \Phi(Z,t)}{\partial Z}}_{\text{deterministic drift}} + \underbrace{\frac{\upsilon^2}{2} Z^2 \frac{\partial^2 \Phi(Z,t)}{\partial Z^2}}_{\text{Brownian motion}}.$$

A solution to this is a truncation

$$\phi(Z,t) = \frac{\phi(Z,0)}{1-\Phi(M(t),0)}$$

The probability density function at date t is a truncation of the initial distribution at the reservation adoption productivity.

The Initial Productivity Distribution

Assumption 1

The initial distributions of productivity are Pareto,

$$\Phi(Z,0) = 1 - \left(\frac{M(0)}{Z}\right)^{\theta} \quad \text{with density} \quad \phi(Z,0) = \theta M(0)^{\theta} Z^{-1-\theta}.$$

Lemma 1

Assumption # 1 and the solution to the KFE implies

$$\phi(Z,t) = \theta M(t)^{\theta} Z^{-1-\theta}.$$

If the initial density is Pareto with shape θ, it remains Pareto with shape θ.

Plan of Attack

In the no GBM, no exit model ask some qualitative questions about the balanced growth path. . .

1. How do changes in variable trade costs affect growth?
2. What is the role of reallocation vs. market size effects?
3. How do changes in variable trade costs affect welfare?

Ask some quantitative questions in the general setup of model. . .

4. Calibrate to aggregate and firm dynamics data.
5. Study a local decomposition to identify the sources of the gains from trade and how they differ from those in an efficient economy.
6. Study a large decrease in trade costs inclusive of the transition path.

Proposition 1 (**Growth on the BGP**)

Given parametric assumptions and parameter restrictions, there exists a unique Balanced Growth Path Equilibrium with growth rate

$$g = \frac{\rho(1-\chi)}{\chi\theta}\frac{\bar{\pi}}{\bar{\pi}_{\min}} - \frac{\rho}{\chi\theta},$$

where

- $\bar{\pi} =$ profits of the average firm.
- $\bar{\pi}_{\min} =$ profits of the marginal, just adopting firm.
- And the profit ratio has the closed form expression

$$\frac{\bar{\pi}}{\bar{\pi}_{\min}} = \frac{\left(\theta + (N-1)(\sigma-1)d^{-\theta}\left(\kappa\frac{\chi}{\rho(1-\chi)}\right)^{1-\frac{\theta}{\sigma-1}}\right)}{(\theta-\sigma+1)}.$$

Proposition 1 (**Growth on the BGP**)

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where

- $\bar{\pi} =$ profits of the average firm.
- $\bar{\pi}_{\text{min}} =$ profits of the marginal, just adopting firm.

Key feature: Growth encodes the trade-off that firms' face in a simple way:

Expected benefits (average profits) vs. the opportunity cost (forgone profits).

Proposition 2 (**Comparative Statics: Trade, Profits, and Growth**)

A decrease in variable trade costs. . .

1. Decreases a country's home trade share

$$\varepsilon_{\lambda_{ii},d} \;=\; \theta(1-\lambda_{ii}) \;>\; 0.$$

2. Increases the spread in profits between the average and marginal firm

$$\varepsilon_{\bar{\pi}_{\text{rat}},d} \;=\; \left(\frac{-(\sigma-1)}{1+\lambda_{ii}(\theta-1)}\right)\varepsilon_{\lambda_{ii},d} \;<\; 0.$$

3. Increases economic growth

$$\varepsilon_{g,d} \;=\; \left(\frac{\chi(1+\theta-\sigma)}{(\sigma-1)(1-\chi)}\lambda_{ii}-1\right)^{-1}\varepsilon_{\lambda_{ii},d} \;<\; 0.$$

Proposition 3 (**Growth with No Selection into Exporting**)

In the model with $\kappa = 0$, in which all firms sell internationally, the growth rate is

$$g = \frac{\rho(1-\chi)}{\chi\theta}\frac{\bar{\pi}}{\bar{\pi}_{\text{min}}} - \frac{\rho}{\chi\theta},$$

where the ratio of average profits to minimum profits is

$$\frac{\bar{\pi}}{\bar{\pi}_{\text{min}}} = \frac{\theta}{1+\theta-\sigma}.$$

Without reallocation effects, trade has no impact on growth.

Consumption Effects

Proposition 4 (**Variety, Labor, and Consumption**)

A decrease in variable trade costs. . .

1. Reduces domestic varieties.

$$\varepsilon_{\Omega,d} = \left(1 - \frac{1+\theta-\sigma}{\theta\sigma(1-\chi)}\lambda_{ii}\right)^{-1} \varepsilon_{\lambda_{ii},d} \; > \; 0.$$

2. Reduces the share of workers in goods production.

$$\varepsilon_{\tilde{L},d} = \left(\frac{\theta\sigma(1-\chi)}{1+\theta-\sigma}\lambda_{ii}^{-1} - 1\right)^{-1} \varepsilon_{\lambda_{ii},d} \; > \; 0.$$

3. Reduces the initial level of consumption.

$$\varepsilon_{c,d} = \varepsilon_{\tilde{L},d} + \frac{\varepsilon_{\Omega,d} - \varepsilon_{\lambda_{ii},d}}{\sigma - 1} < 0.$$

Welfare

Steady-state utility is a function of the level of consumption and its growth rate

$$\bar{U} = \frac{\rho \log(c) + g}{\rho^2}.$$

Proposition 5 (**Welfare Effects**)

The change in utility from a change in trade costs is

$$\varepsilon_{\bar{U},d} = \frac{\rho^2}{\bar{U}} \left(\rho \; \varepsilon_{c,d} + g \; \varepsilon_{g,d}\right).$$

Welfare depends on competing forces. . .

- Loss in consumption level from less varieties, more "investment" in technology adoption.
- Faster economic growth.

Calibration Overview

Pre-selected parameters (essentially normalizations, see the paper for details):

- $N = 10$,
- $\zeta = 1$

Fixed cost, iceberg cost, entry cost, Pareto shape parameter, variety elasticity of substitution, GBM process, exit rate, discount rate picked to target US moments over the 1977–2000 time period:

- Aggregate total factor productivity growth: 0.79 percent.
- Average real interest rate: 2.83 percent.
- Aggregate import share: 10.63 percent
- Share of exporting establishments: 3.3 percent (from Bernard et al. (2003) and our calculations).
- Relative size of exporting establishments: 4.8 from Bernard et al. (2003).
- Size dynamics of establishments from the Synthetic Longitudinal Business Database (SLBD) (U.S. Bureau of the Census (2011)).

Calibration Results: Parameters

Table 1: Calibration Results: Parameters and Values

Parameter	Value	Parameter	Value
Technology Adoption Cost, ζ	1.0	Number of Countries, N	10
Discount Rate, ρ	0.0203	Pareto Shape Parameter, θ	4.99
Variety Elasticity of Substitution, σ	3.17	Drift of GBM Process μ	-0.031
Variance of GBM Process υ^2	0.048	Death Rate of Firms δ	0.020
Iceberg Trade Cost, d	3.02	Export Fixed Cost, κ	0.104
Entry Cost Relative to Adoption Cost $1/\chi$	7.88		

Calibration Results: Fit of Aggregate Moments

Table 2: Aggregate Moments: Model and Data

Moment Description	Data	Model
U.S. Real Interest Rate	2.83	2.83
U.S. Productivity Growth	0.79	0.79
U.S. Import/GDP	10.63	10.63
Share of Exporting Establishments	3.3	3.3
Relative Size of Exporting Establishments	4.8	4.8

Details of moment construction are provided in the body of the paper. The real interest rate, productivity growth rate, and import/GDP ratio are in percent and averages over the 1977–2000 time period.

Calibration Results: Fit of Micro Moments

Table 3: Establishment Size Dynamics, Data and Model

Transition Matrix of Relative Size: largest, quartile 1; smallest, quartile 4

Data

	1	2	3	4
1	50.1	27.0	13.6	9.4
2	16.1	28.5	29.0	26.0

Model

	1	2	3	4
1	45.7	31.5	14.2	8.6
2	17.1	28.8	28.2	25.9

Corr(Data, Model) $= 0.98$

Employment Share of New Establishments

Data: 0.02 Model: 0.02

Note: In the top panel, rows represent the establishment-size quartile in period t; columns represent the establishment-size quartile in period $t+5$. Data Source: U.S. Bureau of the Census (2011).

Local Decomposition of the Gains from Trade

- A feasible allocation can be described as a zero of a system of equations $\Gamma(\Omega, \hat{z}, g; d) = 0$.
- Thus, we can represent the level of consumption as a function $c = f_c(\Omega, \hat{z}, g; d)$.
- There are unique equilibrium values for varieties, the exporter productivity threshold, and the growth rate, which we represent as $\Omega = f_\Omega(d)$, $\hat{z} = f_{\hat{z}}(d)$, and $g = f_g(d)$.
- All indexed by the trade-cost parameter d.

Then totally differential utility (which is a function of c and g) with respect to a small change in d.

$$\frac{\mathrm{d}\bar{U}\left(f_c(\Omega, \hat{z}, g, d), f_g(d)\right)}{\mathrm{d}d} = \bar{U}_1 \frac{\partial f_c}{\partial d} + \bar{U}_1 \left[\frac{\partial f_c}{\partial \Omega}\frac{\mathrm{d}f_\Omega}{\mathrm{d}d} + \frac{\partial f_c}{\partial \hat{z}}\frac{\mathrm{d}f_{\hat{z}}}{\mathrm{d}d} + \frac{\partial f_c}{\partial g}\frac{\mathrm{d}f_g}{\mathrm{d}d}\right] + \bar{U}_2 \frac{\mathrm{d}f_g}{\mathrm{d}d},$$

- The first term is the direct effect of a change in the trade cost on consumption. This direct effect measures the increase in the level of consumption holding fixed factor allocations (labor).
- The second term in the brackets contains the indirect effects of trade costs on consumption through changes in the measure of varieties, the exporter threshold, and the growth rate.
- The final term is the direct effect of a change in the trade cost on growth.

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The idea: use this equation to computationally decompose

- where the gains from trade come from,
- compare to an efficient allocation.

Direct Consumption Effect is Small

Starting from the equilibrium steady state, change d by a small amount. We report the contribution of terms to the total change in welfare...

$$\underbrace{\frac{\mathrm{d}\bar{U}(c,g))}{\mathrm{d}d}}_{\textbf{100\%}} = \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial d}}_{\textbf{8.32\%}} + \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial \Omega}\frac{\mathrm{d}f_\Omega}{\mathrm{d}d}}_{\textbf{-7.28\%}} + \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial \hat{z}}\frac{\mathrm{d}f_{\hat{z}}}{\mathrm{d}d}}_{\textbf{0\%}} + \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial g}\frac{\mathrm{d}f_g}{\mathrm{d}d}}_{\textbf{-9.90\%}} + \underbrace{\bar{U}_2 \frac{\mathrm{d}f_g}{\mathrm{d}d}}_{\textbf{108.86\%}},$$

The direct consumption effect is small.

Hold this thought...computationally, in levels, it corresponds to the value implied by ACR.

Growth Component is Big

Starting from the equilibrium steady state, change d by a small amount. We report the contribution of terms to the total change in welfare. . .

$$\underbrace{\frac{\mathrm{d}\bar{U}(c,g))}{\mathrm{d}d}}_{\textbf{100\%}} = \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial d}}_{\textbf{8.32\%}} + \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial \Omega} \frac{\mathrm{d}f_\Omega}{\mathrm{d}d}}_{\textbf{-7.28\%}} + \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial \hat{z}} \frac{\mathrm{d}f_{\hat{z}}}{\mathrm{d}d}}_{\textbf{0\%}} + \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial g} \frac{\mathrm{d}f_g}{\mathrm{d}d}}_{\textbf{-9.90\%}} + \underbrace{\bar{U}_2 \frac{\mathrm{d}f_g}{\mathrm{d}d}}_{\textbf{108.86\%}},$$

The effects of a change in trade costs on growth are large.

Growth Component is Big due to an Inefficiency

Starting from the equilibrium steady state, change d by a small amount. We report the contribution of terms to the total change in welfare...

$$\underbrace{\frac{\mathrm{d}\bar{U}(c,g))}{\mathrm{d}d}}_{\textbf{100\%}} = \underbrace{\bar{U}_1\frac{\partial f_c}{\partial d}}_{\textbf{8.32\%}} + \underbrace{\bar{U}_1\frac{\partial f_c}{\partial \Omega}\frac{\mathrm{d}f_\Omega}{\mathrm{d}d}}_{\textbf{-7.28\%}} + \underbrace{\bar{U}_1\frac{\partial f_c}{\partial \hat{z}}\frac{\mathrm{d}f_{\hat{z}}}{\mathrm{d}d}}_{\textbf{0\%}} + \underbrace{\left[\bar{U}_1\frac{\partial f_c}{\partial g} + \bar{U}_2\right]\frac{\mathrm{d}f_g}{\mathrm{d}d}}_{\textbf{98.96\%}},$$

Compare the **red** terms to how a constrained planner that faces the same exact resource and technological constraints would chose the growth rate (see details in paper). The planner would set:

$$\left[\bar{U}_1\frac{\partial f_c}{\partial g} + \bar{U}_2\right]\frac{\mathrm{d}f_g}{\mathrm{d}d} = 0$$

$\Rightarrow$ The gains from trade in our model is due to an **inefficiency**, i.e., growth in the decentralized equilibrium is inefficiently low b/c of the externality. And opening to trade partially corrects it.

Growth Component is Big due to an Inefficiency

Starting from the equilibrium steady state, change d by a small amount. We report the contribution of terms to the total change in welfare...

$$\underbrace{\frac{\mathrm{d}\bar{U}(c,g))}{\mathrm{d}d}}_{\textbf{100\%}} = \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial d}}_{\textbf{8.32\%}} + \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial \Omega}\frac{\mathrm{d}f_\Omega}{\mathrm{d}d}}_{\textbf{-7.28\%}} + \underbrace{\bar{U}_1 \frac{\partial f_c}{\partial \hat{z}}\frac{\mathrm{d}f_{\hat{z}}}{\mathrm{d}d}}_{\textbf{0\%}} + \underbrace{\left[\bar{U}_1 \frac{\partial f_c}{\partial g} + \bar{U}_2\right]\frac{\mathrm{d}f_g}{\mathrm{d}d}}_{\textbf{98.96\%}},$$

Is this term big because $\frac{\mathrm{d}f_g}{\mathrm{d}d}$ moves a lot or a large inefficiency (bracketed term)?

Hard to tell, but...

- We show that movements in growth that we find are well within the range of historical variation in the long-run aggregate productivity growth rate.
- Connects with Atkeson and Burstein (2019): the elasticity of growth with respect to innovation policy is likely small, but the welfare gains from small increases in growth can be large.

Standard Models: Only Direct Consumption Effects Matter b.c. of Efficiency

Starting from the equilibrium steady state, change d by a small amount. We report the contribution of terms to the total change in welfare...

$$\underbrace{\frac{\mathrm{d}\bar{U}(c,g))}{\mathrm{d}d}}_{\textbf{100\%}} = \underbrace{\bar{U}_1\frac{\partial f_c}{\partial d}}_{\textbf{8.32\%}} + \underbrace{\bar{U}_1\frac{\partial f_c}{\partial \Omega}\frac{\mathrm{d}f_\Omega}{\mathrm{d}d}}_{\textbf{-7.28\%}} + \underbrace{\bar{U}_1\frac{\partial f_c}{\partial \hat{z}}\frac{\mathrm{d}f_{\hat{z}}}{\mathrm{d}d}}_{\textbf{0\%}} + \underbrace{\left[\bar{U}_1\frac{\partial f_c}{\partial g} + \bar{U}_2\right]\frac{\mathrm{d}f_g}{\mathrm{d}d}}_{\textbf{98.96\%}},$$

Highlights a key issue behind the gains from trade: the (in)efficiency of the equilibrium...

- Atkeson and Burstein (2010): Only the direct consumption effect matters and indirect effects are second order; heterogeneity does not matter. Why? Their economy is efficient.
- Melitz (2003): Same deal—only direct consumption effects matter. Our model differs, not per se because of growth effects, but because growth is not efficient.
- Arkolakis et al. (2012): the direct consumption effect corresponds to the value implied by the ACR formula. But ACR formula does not characterize our gains...b/c of the inefficiency.

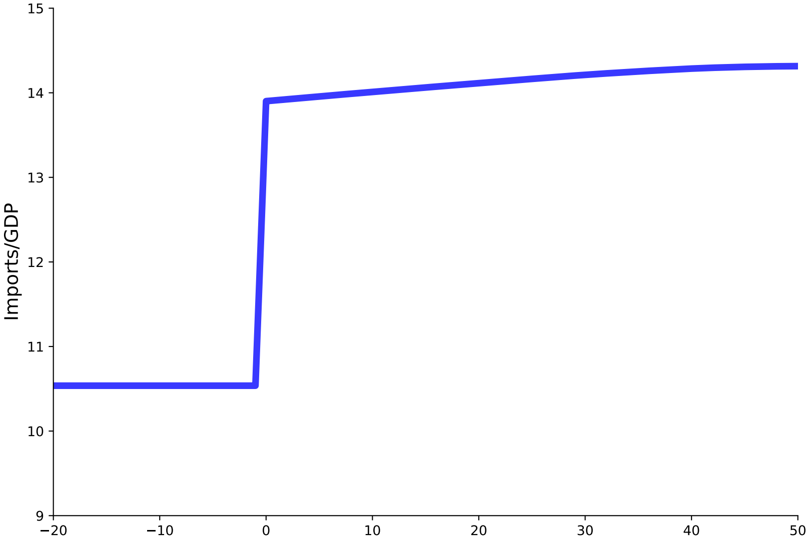
Global Analysis: The Gains from Trade

How does the economy react to a larger reduction in trade costs **inclusive of transition dynamics**?

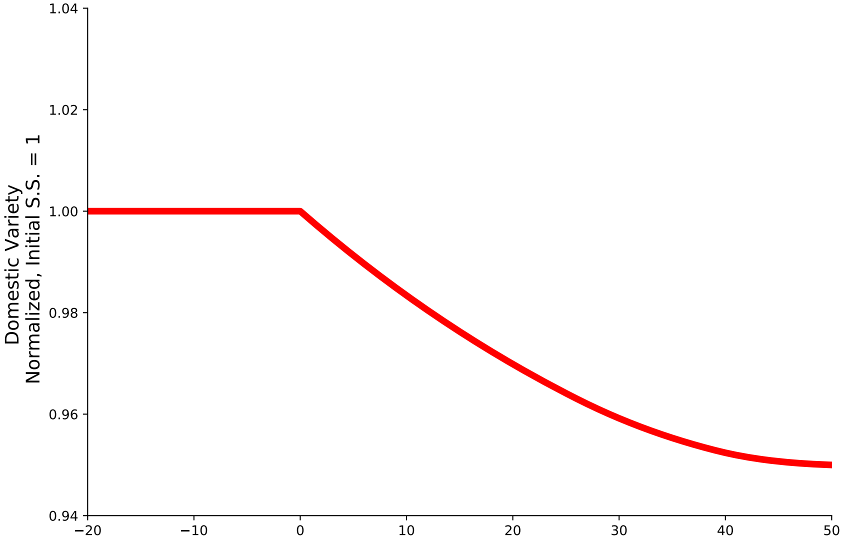
The quantitative experiment...

- Start from the economy on calibrated BGP,
- Shock the economy with an unanticipated ten percent permanent reduction in trade costs,
- Study how the economy transits to the new low-trade-cost BGP equilibrium.

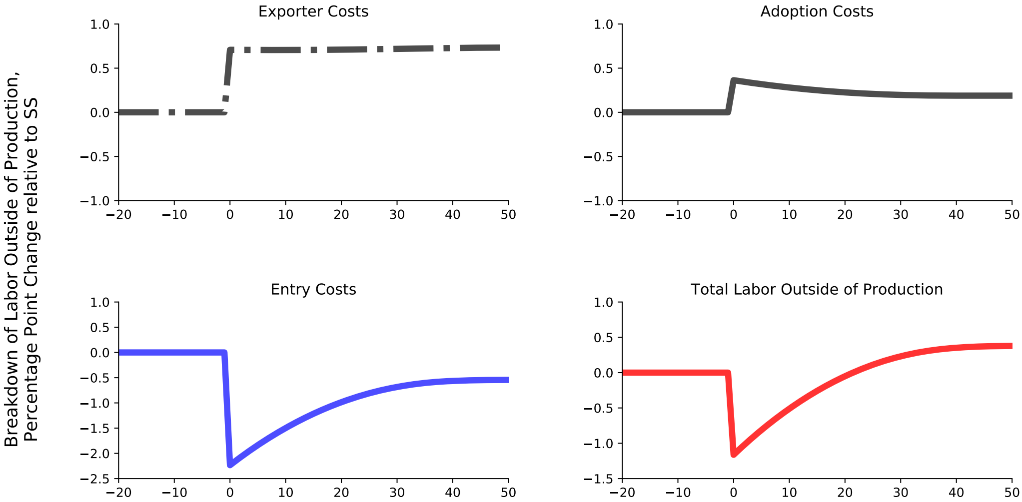
Trade: Near Instantaneous Jump



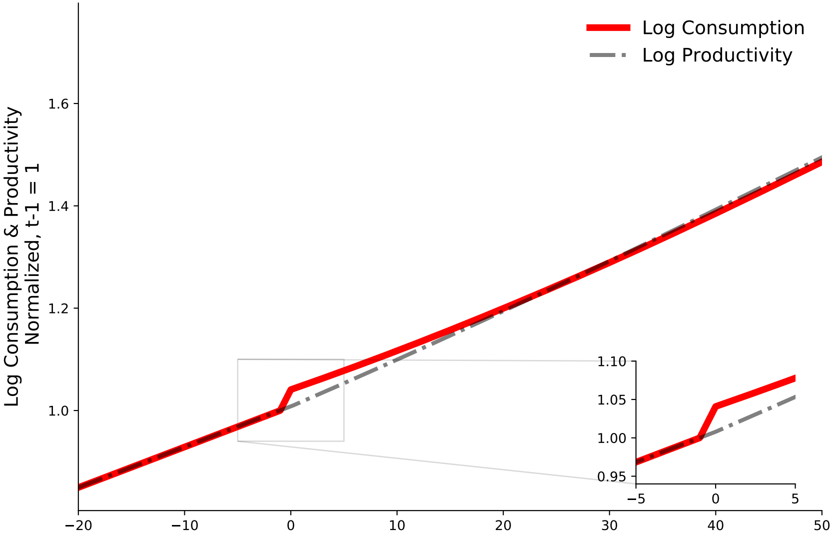
Domestic Variety $\Omega(t)$: Slow Adjustment as Firms Exit, Delayed Entry



Reallocation Effects: Labor Reallocates to Expand Trade and Technology Adoption



Implication # 1: Consumption Level Overshoots



Implication # 2: Productivity Growth Slowly Rises

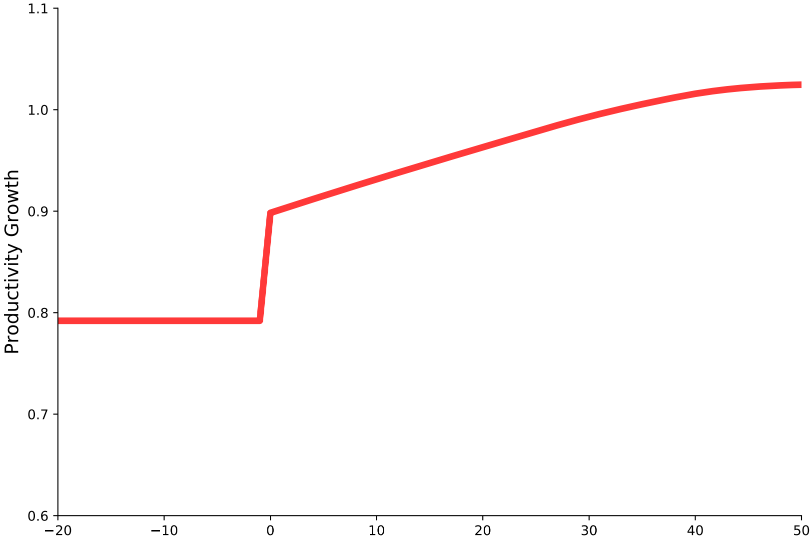


Table 4: 10 Percent Reduction in Trade Costs: Growth, Trade, and Welfare

	Baseline BGP	New BGP
Growth	0.79	1.03
Imports/GDP	10.6	14.4
Welfare		
Consumption Equivalent Gain (Transition Path):		10.8
Consumption Equivalent Gain (SS to SS):		11.2

Note: All values are in percent. Consumption-equivalent is the permanent percent increase in consumption a household requires in the old regime to be indifferent between the new and old regimes.

Welfare Gains from Trade: Comparison to Benchmarks in Literature

1. Arkolakis, Costinot, and Rodriguez-Clare (2012) formula: 0.87% — an order of magnitude smaller.

- Key issue is efficient vs. inefficient. The ACR number closely corresponds to the direct consumption effect which would equal our gains from trade if our economy were efficient.

2. Gains implied by Atkeson and Burstein (2010) (when recalibrated to mimic our economy): 0.85%

- Same deal as with Arkolakis, Costinot, and Rodriguez-Clare (2012).

3. Sampson (2016) important benchmark b/c his model has a similar externality. We recalibrated our economy to match his and study a move to autarky.

- The welfare loss from autarky in our (recalibrated) model is -3.16%; -3.6% in Sampson (2016).
- In our baseline economy, welfare cost of autarky is -5.67%. Key difference is the role that micro-level firm dynamics (GBM parameters) play in shaping strength of externality/ineffeciency.
- Importance of micro-level firm dynamics also mimics Hsieh, Klenow, and Nath (2019).
- See paper Section E for the affect of firm dynamics and adoption cost parameters on welfare gains and on the importance of calibrating to firm dynamics moments.

Final Thoughts

1. Increases in openness can deliver large welfare gains by addressing inefficiencies.

- Not a new idea per se, but our results emphasize this in a transparent nontrivial economic environment with trade and growth disciplined by micro-level data.
- Suggests that understanding the gains from trade may be inherently tied to studying the degree of inefficiency in aggregate economies.

2. Many papers studying the welfare gains of policy interventions reach the conclusions they do because of the size of the inefficiency in their calibrated economies. What pins this down?

- Our paper, Garcia-Macia, Hsieh, and Klenow (2019), Ackigit and coauthors, discipline the size of knowledge externalities using data on firm dynamics + growth theory.
- Very indirect. Research should develop more direct/alternative methods to measure the size of knowledge externalities.

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